PATENT SPECIFICATION

(11) 1 227 444

DRAWINGS ATTACHED

1 227 444

(21) Application No. 23482/68 (22) Filed 17 May 1968
(31) Convention Application No. 108443 (32) Filed 30 May 1967 in
(33) France (FR)
(45) Complete Specification published 7 April 1971
(51) International Classification F 04 f 5/46
(52) Index at acceptance F1E 10A1 1B

(54) IMPROVEMENTS IN AND RELATING TO ASPIRATORS

(71) We, CONDENSEURS DELAS, a French Body Corporate of 8, rue Bellini, Paris 16, Seine, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an aspirator which includes means for directing a high velocity gas stream across an aspiration chamber into a convergent-divergent diffuser.

In a prior form of such a device compression of the gas stream is effected within the diffuser and a shock wave is created in the divergent portion of the diffuser, the high velocity gas stream carrying with it entrained gas from the aspiration chamber whereby the pressure within the chamber is reduced, the aspiration chamber being connected to a vessel the pressure of which is to be reduced.

The divergent portion of the diffuser of such prior aspirator has been of frusto-conical form and the cross-sectional area of the outlet end of an expansion tube through which the high velocity gas stream is introduced into the aspiration chamber has had to be no more than half the minimum cross-sectional area of the diffuser to ensure that the shock wave is maintained within the divergent portion of the diffuser.

Such an aspirator has been found to be unstable when the pressure within the aspiration chamber has varied considerably, for example, for de-gassing molten metals it is required that the aspirator be capable of operating satisfactorily for aspiration pressures varying periodically from 0.01 to 100 Torr.

It is accordingly an object of the present invention to provide a new or improved form of aspirator.

In accordance with the present invention there is provided an aspirator comprising an expansion tube within an aspiration chamber, and a convergent-divergent diffuser aligned with said expansion tube whereby a pressurized fluid introduced into said expansion tube to issue therefrom as a high velocity jet enters the diffuser and is compressed therein, the divergent portion of the diffuser comprising first, second and third co-axial sections, said first section being contiguous with the convergent portion of the diffuser and said second section having an axial length greater than that of said first section and being cylindrical or having an angle of divergence less than said first and third sections.

The invention will now be described by way of example with reference to the accompanying drawing in which:

Figure 1 is a diagrammatic view in longitudinal axial section of a known form of aspirator used for creating a low pressure in an enclosed space.

Figure 2 is a diagrammatic view, also in longitudinal axial section, of a first embodiment of the invention and,

Figure 3 is a diagrammatic view, again in longitudinal axial section, of a second embodiment of the invention.

Figure 1 illustrates a known form of aspirator for creating a low pressure within an enclosed space. The aspirator includes a convergent-divergent expansion tube 1 having an angle of divergence $\propto$ of the order of 7° and the tube 1 is supplied at 2 with steam under pressure from an appropriate source (not shown). The tube 1 opens into an aspiration chamber 3 which is connected by a conduit 4 with the enclosed space (not shown) wherein the low pressure is to be created, and there is a diffuser 5 of convergent-divergent conformation which is arranged co-axially with the tube 1 so that a gas stream delivered into its inlet end is compressed.

Between the source of steam under pressure and the aspiration chamber 3 there is a pressure differential of such order as to produce, at the downstream or outlet end of the tube 1, a high speed jet (currently speeds of up to 1,000 metres per second are being obtained). The mass of steam issuing from said tube per unit time can be considered as m_1 and the steam jet frictionally carries with it ambient fluid from the chamber 3, the mass

of ambient fluid removed from said chamber per unit time can be considered as m_2.

The gas stream with the entrained fluid is partly compressed in the converging portion *5a* of the diffuser 5 and is compressed further in the diverging portion *5b* of said diffuser. The gas stream passes through the neck or smallest cross-sectional portion of the diffuser at a sonic speed and at a pressure which is approximately half the delivery pressure at the outlet of the diffuser. During operation of the aspirator a shock wave is created at 6 in the diverging portion *5b* of the diffuser.

Experience has shown that there are two dimensional requirements which must be satisfied with such an aspirator and the first of these is that the ratio of the cross-sectional area of the outlet end of the tube 1 to the minimum cross-sectional area of the diffuser 5, must be less than or equal to 0.5. The second of these is that the ratio L to D, wherein L is the distance from the outlet end of the tube 1 to the neck of the diffuser and D is the diameter of the neck of the diffuser, must be less than or equal to 7. The two requirements are related and, for a given value of D, the greater the cross-sectional area of the outlet end of the tube 1 the less the value of L.

Such an aspirator has average stability and has a tendency to fail when the value m_2 becomes very small or even 0 and it has been found that the faults inherent in conventional supersonic aspirators are due to the use of a diffuser of simple convergent-divergent conformation with a uniform angle of divergence. It has also been found that in the case of a supersonic aspirator operating at a compression rate in excess of 6, the efficiency of the aspirator is significantly affected by a rapid drop in pressure within the aspiration chamber 3. Such reduction in efficiency is caused by a rapid expansion of the steam jet at the outlet of the tube 1 thereby generating turbulence within the aspiration chamber 3 which interferes with and reduces the efficiency of the jet. Such reduction is all the more noticeable as a result of the cross-sectional area of the outlet end of the tube 1 being small in relation to the minimum cross-sectional area of the diffuser 5. In order to eliminate such turbulent conditions it would be necessary, in theory, to have a tube 1 whereof the outlet end had dimensions substantially equal to those of the neck of the diffuser 5. However, this arrangement cannot be used for, as has been pointed out above, it is required that the cross-sectional area of the end of the tube 1 must be at most equal to half the minimum cross-sectional area of the diffuser 5.

Figure 2 shows a first embodiment of the present invention suitable for operating at compression rates between 2 and 6, the compression rate being the degree of compression obtained within the diffuser. The aspirator of Figure 2 includes a conventional expansion tube 1 as described above and a diffuser 7 having four successive sections, namely a first section *7a* of conventional convergent conformation, a second divergent section *7b* of conventional divergence, i.e. of the order of 15°, the axial length of which is approximately 0.2 to 0.3 times the diameter D of the diffuser neck, a third cylindrical section *7c* the length of which is approximately 8 to 10 times the diameter D of the diffuser neck (it should be noted that in the drawing the section *7c* has been shown in Figure 2 and 3 considerably shorter than it actually is), and a fourth divergent section *7d* of conventional divergence angle, of the order of 20°. The divergent section *7b* which is very short is designed to provide a boundary for the shock wave 6 and to prevent it from passing into the convergent section *7a* of the diffuser which would interrupt operation of the aspirator. The cylindrical section *7c* which follows the section *7b* allows the optimum use to be made of the shock wave 6 for the further compression of the gas stream. The conventional divergent section *7d* allows recuperation of the residual kinetic energy in the gas stream.

The section *7c* may be of low divergence, e.g. a divergence angle of the order of 1°, instead of being cylindrical as illustrated. It is always an advantage, however, to use the smallest possible angle of divergence in order to ensure that the ratio m_2 plus m_1 to m_1 should be as large as possible so as to obtain the widest possible operation range for the aspirator. The choice of the cylindrical conformation of the section *7c* is of advantage in the production of the aspirator since in this way it is possible to make the section *7c* from commercially available tubular material.

Figure 3 shows a second embodiment of the present invention which is suitable for operating at compression rates higher than 6. The aspirator of Figure 3 comprises in addition to the diffuser 7 described with reference to Figure 2, and expansion tube 8 which includes two divergent sections of relatively increasing divergence, namely a first section *8a* having an angle of divergence α less than 10°, for example of the order of 7°, and a second section *8b* having an angle of divergence, β, between 20° and 60°, e.g. of the order of 40°. The cross-sectional area of the end of the tube section *8a* is of the order of half the minimum cross-sectional area of the diffuser 7 in order to allow starting of the aspirator and the cross-sectional area of the end of the tube section *8b* is approximately equal to said minimum cross-sectional area to afford the best possible output. The distance L between the outlet end of the tube section

8a and the neck of the diffuser must be less than or equal to 7 times the diameter of the neck of the diffuser as in conventional aspirators as shown in Figure 1.

The use of the doubly divergent expansion tube 8 permits an increase in the output of the aspirator, particularly when the pressure within the aspiration chamber 3 is low, for example, in the final phase of an evacuation process. The expansion tube 8 functions as follows:

at the beginning of an evacuation process the pressure in the aspiration chamber 3 is comparatively high, for example, atmospheric pressure. Since the first tube section 8a has a small angle of divergence, for example 7°, the stream jet which passes therethrough has substantially constant velocities in a given cross-section. The static pressure is also substantially constant in a given cross-section. The steam jet leaving the tube section 8a does not follow the walls of tube section 8b because of the discontinuity of the tube wall profile and the larger angle of divergence in the tube section 8b. When the pressure within the aspiration chamber 3 falls the jet leaving the tube section 8a will tend to follow the walls of tube section 8b and expansion of the jet within the aspiration chamber occurs progressively in a manner indicated by the arrows in Figure 3. In this way, turbulence is reduced to a minimum and can only very slightly impair the power of the jet so that the aspirator has a high output.

The form of aspirator shown in Figure 3 provides a workable and satisfactory compromise between the need to conserve the starting qualities of the jet stream and the need to have a large cross-sectional area end portion of the expansion tube to reduce turbulence. The provision of the three-section divergent portion of the diffuser improves the stability of the aspirator and makes it much more simple to adjust and control operations of the aspirator. An appreciable reduction in the time required to establish predetermined low pressure conditions within an enclosure is thus obtained.

WHAT WE CLAIM IS:—

1. An aspirator comprising an expansion tube within an aspiration chamber, and a convergent-divergent diffuser aligned with said expansion tube whereby a pressurized fluid introduced into said expansion tube to issue therefrom as a high velocity jet enters the diffuser and is compressed therein, the divergent portion of the siffuser comprising first, second and third co-axial sections, said first section being contiguous with the convergent portion of the diffuser and said second section having an axial length greater than that of said first section and being cylindrical or having an angle of divergence less than said first and third sections.

2. An aspirator according to Claim 1 in which the axial length of the first section of the divergent portion of the diffuser is approximately 0.2 to 0.3 times the diameter of the minimum diameter portion of the diffuser.

3. An aspirator according to Claim 2 wherein the length. of the second section of the divergent portion of the diffuser is approximately 8 to 10 times the diameter of the minimum diameter portion of the diffuser.

4. An aspirator according to Claim 1 wherein the expansion tube includes two sections of relatively increasing divergence angle, the first section having a divergence angle less than 10° and the second section having a divergence angle between 20° and 60°.

5. An aspirator according to Claim 4 in which the cross-sectional area of the end of the first section of the expansion tube is not greater than half the minimum cross-sectional area of the diffuser and in which the cross-sectional area of the end of the second section of the expansion tube is greater than half the minimum cross-sectional area of the diffuser.

6. An aspirator according to Claim 5 in which the cross-sectional area of the end of the second section of the expansion tube is approximately equal to the minimum cross-sectional area of the diffuser.

7. An aspirator comprising an expansion tube within an aspiration chamber, and a diffuser aligned with said expansion tube whereby a pressurized fluid introduced into said expansion tube to issue therefrom as a high velocity jet enters the diffuser, the diffuser comprising a generally convergent portion in which a shock wave is created and a generally divergent portion which comprises successively a divergent entry portion having an axial length approximately 0.2 to 0.3 times the diameter of the minimum diameter portion of the diffuser, a substantially cylindrical middle portion having an axial length approximately 8 to 10 times the diameter of the minimum diameter portion of the diffuser, and a divergent outlet portion.

8. An aspirator as claimed in Claim 1 constructed and arranged to operate substantially as hereinbefore described with reference to Figure 2 of the accompanying drawing.

9. An aspirator as claimed in Claim 1 constructed and arranged to operate substantially as hereinbefore described with reference to Figure 3 of the accompanying drawing.

FORRESTER, KETLEY & Co.,
Chartered Patent Agents,
Rutland House,
148 Edmund Street,
Birmingham, 3,
and
Jessel Chambers,
88-90 Chancery Lane,
London, W.C.2.

(8086) Printed by Her Majesty's Stationery Office Press, Edinburgh, 1971.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

1227444 COMPLETE SPECIFICATION

1 SHEET This drawing is a reproduction of the Original on a reduced scale

Fig.1

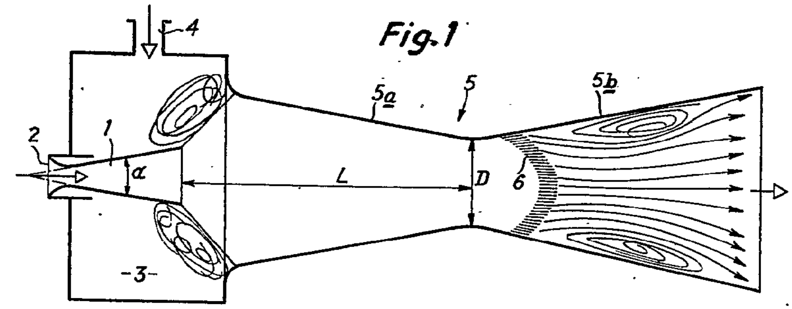

Fig.3

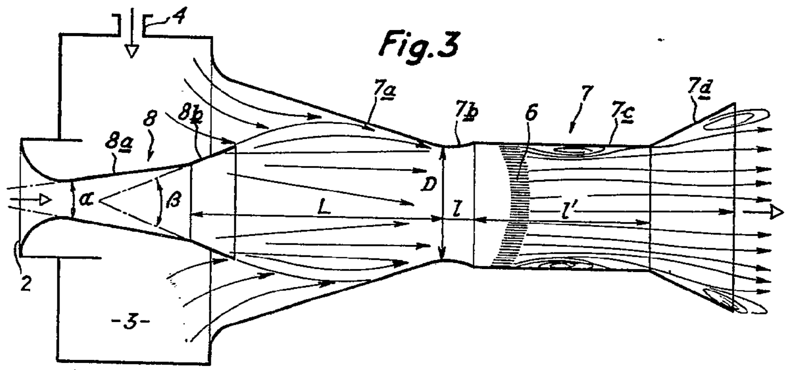

Fig.2